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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

FOREST PEST MANAGEMENT

STATE & PRIVATE FORESTRY

INTERMOUNTAIN REGION

R4-83-7
April 1983

AN EVALUATION OF DISEASE AND INSECT CONDITIONS IN A SPRUCE-FIR STAND ON THE BEAVER RANGER DISTRICT, FISHLAKE NATIONAL FOREST

By
Borys M. Tkacz, Plant Pathologist

ACKNOWLEDGEMENT

Appreciation is extended to LaGrande Hobbs, Paul Fredrick, and Ann Keysor for assistance in fieldwork and data analysis.

INTRODUCTION

Forest Pest Management (FPM) aerial surveys, over the past 15 years, have detected chronic subalpine fir and Engelmann spruce mortality on the Fishlake National Forest in central Utah. Widespread mortality of subalpine fir was detected from 1978 to 1980. Similar mortality has occurred in spruce-fir stands throughout Utah. A ground survey of stands on the Dixie National Forest revealed that the mortality was caused by several species of root diseases and bark beetles (Tkacz and Holland 1983). At the request of Ronald Sanden, Forester, Fishlake National Forest, an FPM field crew conducted a ground survey of a spruce-fir stand on the Beaver Ranger District to determine the causes and extent of tree mortality.

OBJECTIVES

The objectives of this evaluation are to provide information on stocking, basal area, and volume losses due to disease and insect activity in the stand. A range of management alternatives and their expected effects on pest conditions will be presented.

METHODS

The survey was conducted by FPM personnel on August 23-27, 1982. The stand surveyed is located west of Circleville Mountain on the Beaver Ranger District, Fishlake National Forest (T. 30 S., R. 5 W., Sec. 16) (Fig. 1). Survey lines were located on aerial photos (scale 1:15,840) of the stand to avoid existing patchcuts (Fig. 2). Variable radius plots (BAF 20) were established every 5 chains along the survey lines.

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EXPERIMENT STATION

The following data were collected for each tree: species, diameter at breast height (DBH) in inches, total height in feet, condition (healthy, infected, or dead within last 10 years), and cause of infection or mortality. All trees greater than or equal to 5 inches DBH were recorded on the variable plots. All dead or symptomatic trees were examined for the presence of insects or diseases. Two roots on opposite sides of these trees were excavated out to 3 feet and examined for external or internal evidence of root diseases. If positive field identification could not be made, samples of stained or decayed wood were extracted and returned to the laboratory for culturing and identification. The roots and bole of each tree were examined for signs of bark beetle activity. Bark was removed on infested trees for field determination of the species of bark beetles present. The crowns of all trees were examined for signs or symptoms of other diseases, such as rusts. Data collected were used to calculate mean number of trees, basal area, and volume per acre by tree species, DBH class, condition, and pest.

RESULTS

The stand consisted primarily of Engelmann spruce with lesser amounts of subalpine fir (Table 1). Twenty percent of the trees, representing 13 percent of the basal area (BA/A) and 12 percent of the cubic-foot volume (CF/A), had been killed over the last 10 years. An additional 4 percent of the trees, representing 5 percent of the BA/A and 6 percent of the CF/A, were alive but had been attacked by diseases or insects (Table 1). Most of the dead trees were subalpine fir. Ninety-four percent of the Engelmann spruce were healthy (Table 2), but only 40 percent of the subalpine fir were healthy (Table 3). Fifty-six percent of the subalpine and 2 percent of the Engelmann spruce had been killed. Most of the dead subalpine fir were less than 10 inches DBH; whereas, dead Engelmann spruce were larger than 10 inches DBH (Tables 2 and 3).

Root rots caused by Fomes annosus and Armillaria mellea were infecting and killing subalpine fir throughout the stand. Thirty-two percent of the dead subalpine fir had been killed by F. annosus, 36 percent were killed by bark beetles (mostly Dryocoetes confusus, Pityophthorus spp., and Pityokteines spp.) and F. annosus, 9 percent were killed by A. mellea (alone or with bark beetles), and 23 percent were killed by the bark beetles alone (Table 4). One live, disease-free subalpine fir had been attacked by bark beetles. Root rots caused by Fomes annosus and Inonotus tomentosus were found on infected and killed Engelmann spruce.

DISCUSSION

The most frequently encountered disease in the survey area was root rot caused by Fomes annosus. This disease has been found throughout the Intermountain Region (Tegethoff 1973). Although all conifers can be infected with this disease, true firs are especially susceptible.

This fungus spreads by airborne spores which are produced on fruiting bodies or "conks". These conks are often found in old stumps and snags or at the root collar of infected trees. Spores which land on freshly cut stumps or wounds

can germinate and colonize the wood. The fungus then grows through the roots and spreads to adjacent trees by root contacts or grafts. F. annosus can survive for long periods of time in infected stumps and can infect susceptible regeneration on the site through root contacts. Infection by this fungus results in loss of vigor, decay of the butt and roots, and mortality. Infected trees are susceptible to attack by bark beetles or other diseases, such as A. mellea. Armillaria root rot and the western balsam bark beetle (Dryocoetes confusus) were killing F. annosus-infected subalpine fir in the survey area. Many subalpine fir were directly killed by F. annosus. Control of this disease is best accomplished by preventing spore infection of freshly cut stumps.

Borax (sodium tetraborate) prevents establishment of Fomes annosus in cut stumps of trees not already infected (Nelson and Li 1980). This chemical can be easily applied to stumps by using shaker-top applicators. One pound of granular Borax is sufficient to cover 50 square feet of stump surface. This control method is highly recommended for high-value sites, such as developed recreation sites. Other methods which also reduce losses due to F. annosus include timing of cutting to coincide with hot, dry weather, preventing wounds and encouraging regeneration of tree species less susceptible to this pathogen than subalpine fir. Results of the present survey indicate that Engelmann spruce may be more resistant to killing by this disease than subalpine fir.

Western balsam bark beetle is commonly associated with root-diseased subalpine fir and often invades trees following infection by root diseases (James and Goheen 1981). This bark beetle introduces pathogenic stain fungi into attacked trees which aid in killing the trees (Molnar 1965). Ceratocystis dryocoetidis, the most virulent of these stain fungi, causes cambial and inner-bark necrosis with subsequent tree mortality. Western balsam bark beetle has a 2-year life cycle, with adult beetles attacking trees from late June through August. Reducing levels of Fomes annosus infection in the stand and increasing tree vigor will reduce mortality from western balsam bark beetle.

Armillaria mellea (alone and with bark beetles) was killing some subalpine fir in the surveyed stand. This fungus survives as a saprophyte in stumps or snags and is capable of infecting trees through root contacts or by growth through the soil. A. mellea is usually a weak pathogen and normally kills trees stressed by other causes. Trees stressed by Fomes annosus are often additionally attacked by A. mellea. Direct control of Armillaria root rot involves stump removal and is costly. Losses can be reduced by increasing tree vigor through thinning. Although infection by A. mellea may not kill a vigorous tree, loss of structural stability can occur due to decay of the roots.

Four percent of the Engelmann spruce BA/A was infected or killed by Inonotus tomentosus (Table 4). This root-rotting fungus can be very damaging to spruce stands (Tkącz 1983, Whitney 1977). Disease centers are initiated by spore-infection of wounded roots or by mycelium from previously diseased roots. The fungus may survive for periods up to 20 years, following the death of the host (Whitney 1977). The main spread within a stand is by root contacts between healthy and diseased roots. Gradual killing of roots by I. tomentosus results

in appreciable reductions in height and diameter growth long before death of the host tree. Decay of main supporting roots greatly reduces windfirmness and may lead to windthrow of green trees. Tree-to-tree spread of the disease and windthrow of infected trees results in expanding openings in the stand. Susceptible regeneration in these openings becomes infected when roots contact buried residual roots of previously killed spruce. Therefore, harvesting infected stands and regenerating with susceptible species perpetuates the disease. Levels of I. tomentosus infection indicated by the present survey are not high enough to cause much damage to the succeeding stand by rotation age; however, careful examination of stumps following harvest may reveal more infected trees. If infected stumps are widely distributed, special treatment of infection centers may be warranted to reduce infection of the regeneration. Areas containing large concentrations of infected stumps should be cleared of infected woody material or regenerated to resistant hardwoods.

MANAGEMENT ALTERNATIVES

The following management alternatives are available for the surveyed stand and are arranged in increasing order of effectiveness in reducing losses due to diseases and insects:

1. No Action - Losses due to root disease- and insect-caused mortality will continue at the current rate of 5 S/A/yr., representing 57 CF/A/yr. This estimate does not include growth loss in living trees due to infection. Most of the mortality will be in subalpine fir and will be clumped in discrete centers. Drought years will accelerate the rate of insect-caused mortality. The mortality rate will drop as most of the subalpine fir are eliminated from the stand.

2. Salvage Cutting - Much of the volume killed will be salvaged; however, the mortality rate will not be reduced. Repeated entries may, in fact, accelerate root disease infection rate if residual trees are wounded during operations and fresh-cut stumps are not treated to prevent spread of the disease.

3. Salvage/Sanitation Cutting - Combining salvage and sanitation cutting will be effective in harvesting existing and potential mortality. Vigor of remaining trees may be increased. Thinning in heavily infected areas may be followed by increased windthrow of crop trees. Infected trees will not release following thinning. Stumps should be treated with Borax during cutting to prevent new Fomes annosus infections. Subalpine fir should be discriminated against during thinning, since it is more susceptible to root diseases than Engelmann spruce. If stands can be entered frequently (i.e., at 5-year intervals), harvest dead and visibly affected trees. If stand entries cannot be made at intervals of less than 10-15 years, harvest all visible affected trees and all susceptible trees within 30 to 40 feet. These treatments will not retard the spread of root diseases but will salvage useable volume.

4. Patch or Stand Clearcutting - All infected or killed trees in root disease centers should be cut, including those in a 60-foot buffer strip. Established Engelmann spruce regeneration should be retained unless Inonotus tomentosus is

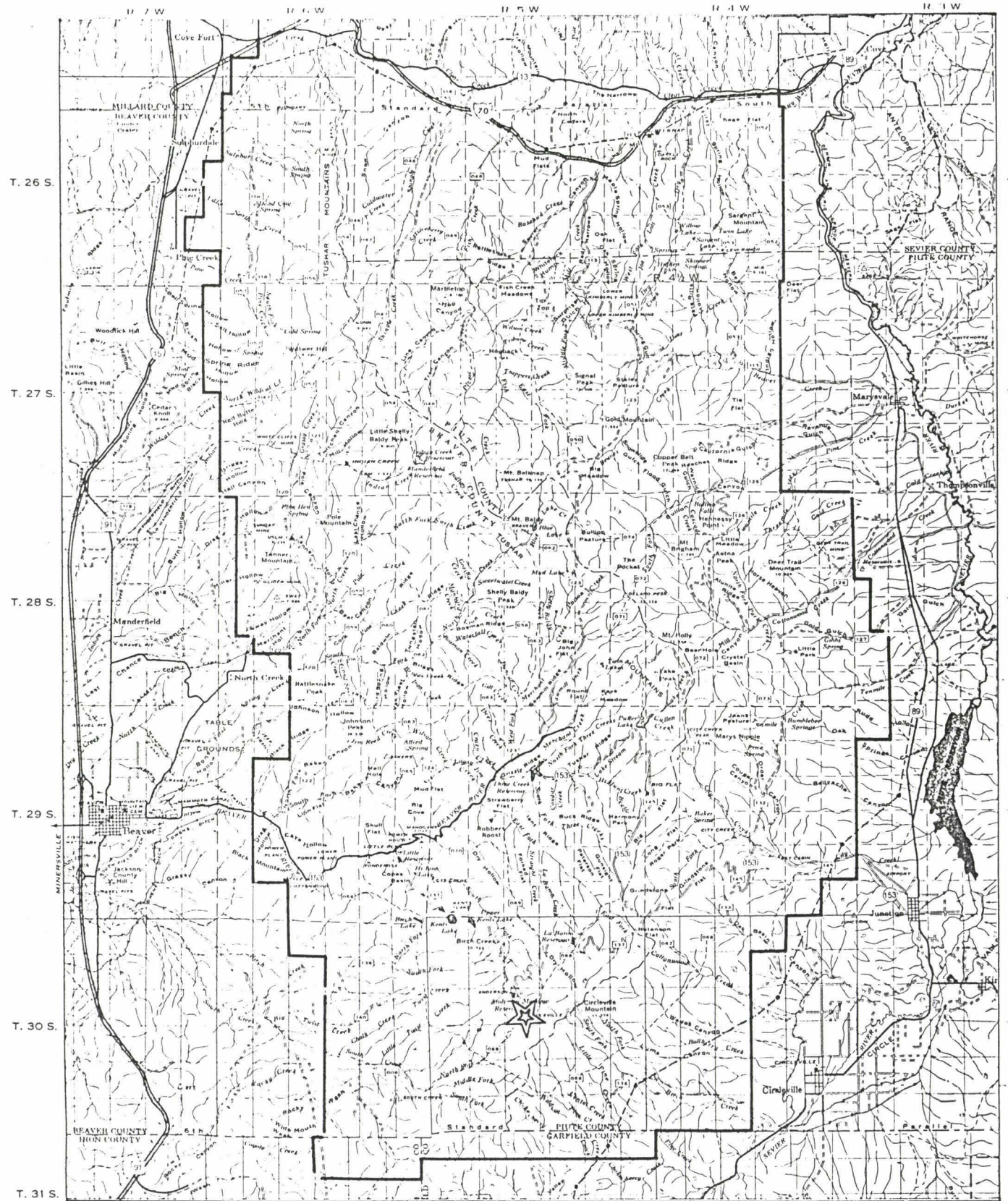
present in stumps. Freshly cut, uninfected stumps should be treated with Borax to prevent Fomes annosus infection. Unless the cuts will be planted, the size of openings should be small enough to encourage Engelmann spruce regeneration. If infection by any of the root diseases is widespread in the remaining stumps, losses will be substantial in the succeeding stand unless the infected stumps are removed. Stumps should be examined immediately following harvest operations, and infection centers should be marked. Replacement of mature Engelmann spruce and subalpine fir with spruce regeneration will reduce disease- and insect-caused mortality and growth loss. Encroachment of aspen and shrubs into disease-caused openings will allow the root rot fungi to die out of residual stumps. After about 50 years, the area can be safely regenerated to susceptible conifer species.

The alternatives presented above should be evaluated by District personnel to determine which would be compatible with the management objectives for the stand. During harvesting of mature spruce, precautions should be taken to prevent spruce beetle buildup in the area. Spruce should be cut as low to the ground as possible to reduce stump height, preferably less than 1.5 feet. Complete removal or destruction of larger-diameter (>12") logs, tops, and branches will prevent buildup of bark beetles. If removal of large-diameter slash is not possible, the slash should be scattered into areas receiving maximum sunlight, treated with chemicals, or burned.

Where a substantial spruce beetle population exists in the adjacent forest, it may be wiser to leave the logging residuals rather than remove or destroy them immediately after cutting. Since the beetles will seek host material as they emerge, suitable residuals will attract beetles and reduce mortality of standing trees. After infestation, the residuals must be removed or treated (Schmid 1977).

An approved pesticide-use proposal (FSM 2151) and supporting documents (FSM 3433) must be on file at the Supervisor's Office for any projects utilizing chemicals, including treatment of slash to prevent spruce beetle buildup and treatment of conifer stumps with Borax to prevent Fomes annosus infection.

The information and recommendations in this report have been specifically formulated for the area surveyed. Although this information may be applicable to other areas, conditions may be different enough to warrant separate biological evaluations. Forest Pest Management personnel are available to conduct such evaluations at the request of land managers.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T. 26 S.
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Cove Fort
MILLARD COUNTY
BEAVER COUNTY
Sulphurdale
Standard
The Narrows
South
Pine Creek
TUSHAR MOUNTAINS
Marbletop
Fish Creek Meadows
Woodtick Hill
Gillies Hill
Cedar Knoll
Little Shelly Baldy Peak
BEAVER COUNTY
PIUTE COUNTY
Mt. Belknap
Mt. Baldy
Pole Mountain
Tanner Mountain
Manderfield
North Creek
TABLE GROUNDS
Beaver
MINERSVILLE
Jackson County Hill
Sugarloaf Mountain
Skull Flat
Robbers Roost
Big Cove
Kents Lake
Birch Creek
Circleville Mountain
Circleville
Junction
Marysvale
Thompsonville
Gold Mountain
Big Meadow
Mt. Baldy
Mt. Belknap
Mt. Holly
Aetna Peak
Deer Trail Mountain
Sargent Mountain
Twin Lakes
Tidy Top
Signal Peak
Tie Flat
Bullion Pasture
The Pocket
Shelly Baldy Peak
Rattlesnake Peak
Big Flat
Strawberry Flat
Harmony Park
Buck Ridge
Three Creeks
Puffer Lake
Cullen Creek
Jeans Pasture
Mary's Nipple
Bumblebee Springs
Deer Trail Mountain
Aetna Peak
Little Meadow
Mt. Baldy
Mt. Belknap
Mt. Holly
Bullion Pasture
Big Meadow
Copper Belt Peak
California Gulch
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Gold Creek
Ravens Gulch
Tie Flat
Signal Peak
Stokes Pasture
Tidy Top
Sargent Mountain
Twin Lakes
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Gillies Hill
Cedar Knoll
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Pole Mountain
Tanner Mountain
Manderfield
North Creek

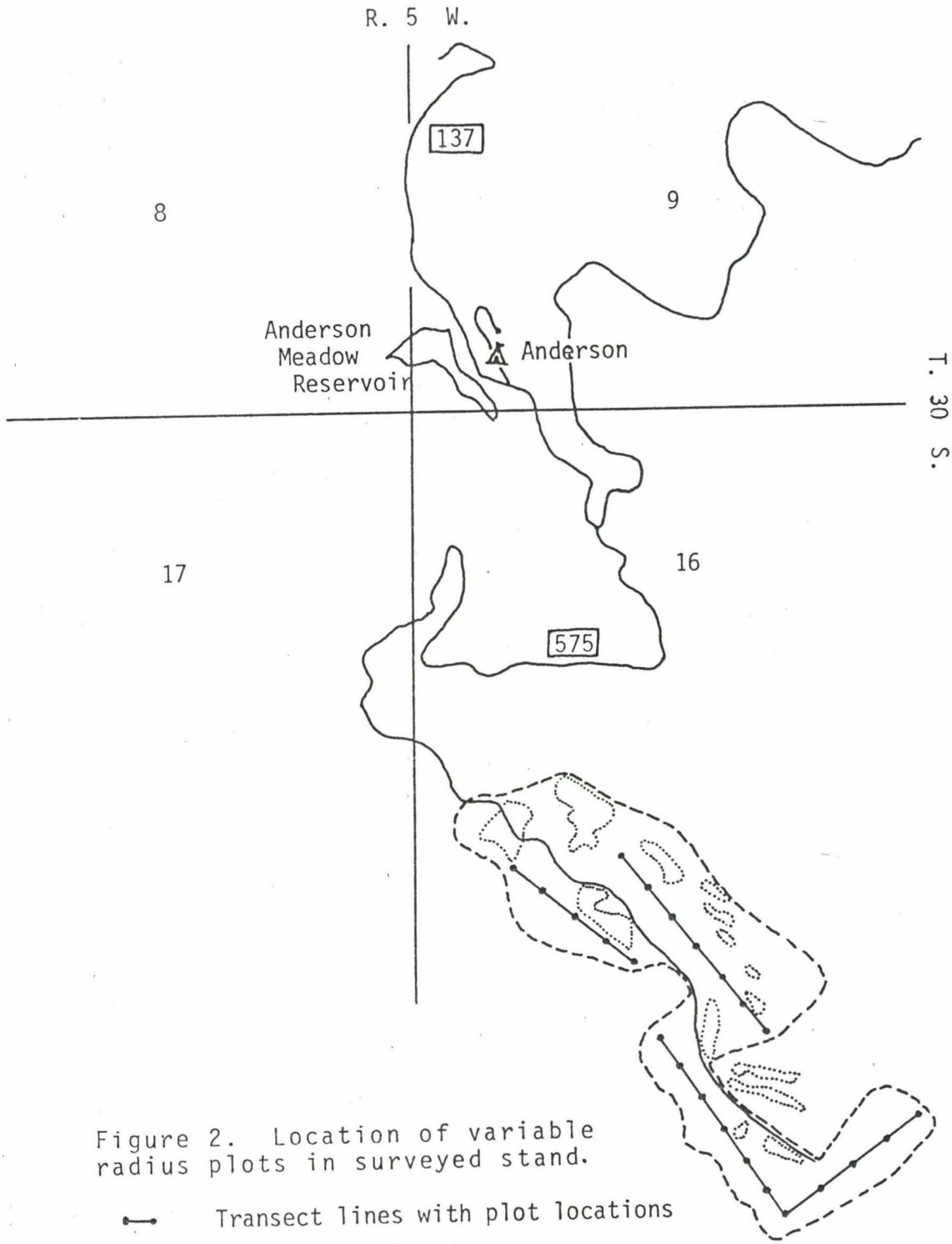

Figure 2. Location of variable radius plots in surveyed stand.

- Transect lines with plot locations
- Existing patch cuts
- Stand boundary
- Campground
- Forest developed road number

Scale 1:15,840

NORTH

Table 1. Stems per acre (S/A), basal area per acre (BA/A), and cubic foot volume per acre (CF/A) of trees by species and condition class.

SPECIES	HEALTHY			INFECTED			DEAD			TOTAL ALL CONDITIONS		
	S/A	BA/A	CF/A	S/A	BA/A	CF/A	S/A	BA/A	CF/A	S/A	BA/A	CF/A
Engelmann spruce	160.0[a] (83)[a]	127.2[a] (89)[a]	3499.2[a] (89)[a]	6.9 (70)	8.0 (83)	241.8 (86)	3.4 (7)	4.8 (21)	151.9 (27)	170.3 (62)	140.0 (80)	3892.9 (82)
Subalpine fir	33.3[a] (17)[a]	16.0[a] (11)[a]	413.1[a] (11)[a]	3.0 (30)	1.6 (17)	40.9 (14)	46.5 (93)	17.6 (79)	408.9 (73)	82.8 (33)	35.2 (20)	862.9 (18)
Total both species	193.3[b] (76)[b]	143.2[b] (82)[b]	3912.3[b] (82)[b]	9.9 (4)	9.6 (5)	282.7 (6)	49.9 (20)	22.4 (13)	560.8 (12)	253.1 (100)	175.2 (100)	4755.8 (100)

a. Percent of condition total for both species.

b. Percent of total all conditions for both species.

Table 2. Stems per acre (S/A), basal area per acre (BA/A), and cubic foot volume per acre (CF/A), of Engelmann spruce by diameter and condition classes.

DBH (in.)	AVG. HT. (ft.)	HEALTHY			INFECTED			DEAD			TOTAL ALL CONDITIONS		
		S/A	BA/A	CF/A	S/A	BA/A	CF/A	S/A	BA/A	CF/A	S/A	BA/A	CF/A
6	51	24.4	4.8	107.8	0	0	0	0	0	0	24.4	4.8	107.8
8	46	29.8	10.4	202.0	2.3	0.8	15.5	0	0	0	32.1	11.2	217.6
10	53	33.7	18.4	398.8	0	0	0	0	0	0	33.7	18.4	398.8
12	64	27.5	21.6	555.6	2.0	1.6	41.2	1.0	0.8	20.6	30.6	24.0	617.4
14	68	16.5	17.6	477.5	0	0	0	1.5	1.6	43.4	18.0	19.2	520.9
16	71	12.0	16.8	473.8	0.6	0.8	22.6	0	0	0	12.6	17.6	496.4
18	82	7.2	12.8	415.3	0.5	0.8	26.0	0.5	0.8	26.0	8.1	14.4	467.2
20	78	4.0	8.8	217.3	1.1	2.4	74.0	0	0	0	5.1	11.2	345.2
22	93	1.5	4.0	147.5	0	0	0	0.3	0.8	29.5	1.8	4.8	117.0
24	99	1.8	5.6	210.8	0.3	0.8	30.1	0	0	0	2.0	6.4	240.9
26	98	0.7	2.4	87.4	0	0	0	0	0	0	0.7	2.4	87.4
28	94	0.6	2.4	82.7	0	0	0	0	0	0	0.6	2.4	82.7
30	115	0	0	0	0.2	0.8	32.5	0.2	0.8	32.5	0.3	1.6	64.9
32	120	0.1	0.8	33.4	0	0	0	0	0	0	0.1	0.8	33.4
34	---	0	0	0	0	0	0	0	0	0	0	0	0
36	130	0.1	0.8	35.3	0	0	0	0	0	0	0.1	0.8	35.3
Total All Diameters		160.0 (94)[a]	127.2 (91)[a]	3499.2 (90)[a]	6.9 (4)	8.0 (6)	241.8 (6)	3.4 (2)	4.8 (3)	151.9 (4)	170.3 (100)	140.0 (100)	3892.9 (100)

a. Percent of total all conditions.

Table 3. Stems per acre (S/A), basal area per acre (BA/A), and cubic foot volume per acre (CF/A) of subalpine fir by diameter and condition classes.

DBH (in.)	AVG. HT. (ft.)	HEALTHY			INFECTED			DEAD			TOTAL ALL CONDITIONS		
		S/A	BA/A	CF/A	S/A	BA/A	CF/A	S/A	BA/A	CF/A	S/A	BA/A	CF/A
6	47	12.2	2.4	55.6	0	0	0	16.3	3.2	74.1	28.5	56	129.7
8	51	11.5	4.0	85.1	2.3	0.8	17.0	18.3	6.4	136.1	32.1	11.2	238.2
10	57	2.9	1.6	34.9	0	0	0	8.8	4.8	104.6	11.7	6.4	139.4
12	74	4.1	3.2	85.4	0	0	0	1.0	0.8	21.3	5.1	4.0	106.7
14	85	0.7	0.8	23.9	0.7	0.8	23.9	1.5	1.6	47.8	3.0	3.2	95.6
16	90	0.6	0.8	25.0	0	0	0	0.6	0.8	25.0	1.1	1.6	50.0
18	--	0	0	0	0	0	0	0	0	0	0	0	0
20	98	0.7	1.6	53.7	0	0	0	0	0	0	0.7	1.6	53.7
22	100	0.3	0.8	25.1	0	0	0	0	0	0	0.3	0.8	25.1
24	--	0	0	0	0	0	0	0	0	0	0	0	0
26	110	0.2	0.8	24.6	0	0	0	0	0	0	0.2	0.8	24.6
Total all Diameters		33.3[a] (40)	16.0[a] (45)	413.1[a] (48)	3.0 (4)	1.6 (5)	40.9 (5)	46.5 (56)	17.6 (50)	408.9 (47)	82.8 (100)	35.2 (100)	862.9 (100)

a. Percent of total all conditions.

Table 4. Basal area per acre (sq. ft.) of infected and dead trees by species and causal agent.

CAUSAL AGENT	SUBALPINE FIR		ENGELMANN SPRUCE		BOTH SPECIES	
	Infected	Dead	Infected	Dead	Infected	Dead
Fomes annosus		5.6 (32)[a]	0.8 (10)	2.4 (50)	0.8 (8.5)	8.0 (35)
Armillaria mellea		0.8 (4.5)				0.8 (4)
Bark beetles	0.8 (50)	4.0 (23)			0.8 (8.5)	4.0 (18)
F. annosus/bark beetles		6.4 (36)				6.4 (28)
A. mellea/bark beetles		0.8 (4.5)				0.8 (4)
Inonotus tomentosus			4.8 (60)	0.8 (17)	4.8 (50)	0.8 (4)
Other decays	0.8 (50)		2.4 (30)	1.6 (33)	3.2 (33)	1.6 (7)
Total all agents	1.6 (100)	17.6 (100)	8.0 (100)	4.8 (100)	9.6 (100)	22.4 (100)

a. Percent of total all agents.

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